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Occurrence and Behavior of Water in Feldspar Crystals and Melt Inclusions in Igneous Rocks

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Beamline(s): U10B

Introduction: Fourier transform infrared (FTIR) spectroscopy was used to identify H-O bonds in minerals and glass from several igneous complexes, including: 1) anorthoclase feldspar from Mount Erebus in Antarctica, 2) glass from 28 million-year-old flow-banded lavas from the Atascosa Mountains of southern Arizona, and 3) 400 million-year-old microcline feldspar megacrysts from the Lexington batholith of central Maine. The anorthoclase crystals have provided the opportunity to correlate crystalline water concentrations with crystallographic orientation, and to correlate water concentrations derived from FTIR work with those established previously by ion microprobe analysis (Dunbar et al., 1994). The flow-banded rhyolite samples provide the opportunity to test the hypothesis that: 1) water bubbles in lavas are pulled apart as the lava flows, and might be the explanation for banded lavas, and that 2) spherulites, glassy spherically-shaped mixtures of quartz and feldspar, might originate by nucleation of magma on water vapor bubbles during magma depressurization quenching. The microcline crystals have provided the opportunity to identify absorption bands representing different species of water in different structural states of the microcline in single crystals

Methods and Materials: The Nicolet Magna 860 Step-Scan FTIR spectrometer on beamline U10B was used in transmission mode to collect spectra on ~12 x 12 micron spots. Samples were 40-micron-thick self-supporting polished rock slabs. In addition, maps were collected over areas of interest in the specimens. The maps were processed to show variation in area under bands from 3100-3600/cm, the range over which the most prominent O-H bands occur.

Results: 1) In the flow-banded rhyolites from the Atascosa Mountains of southern Arizona, bands with coarse spherules are more water-rich than those with finer spherules, and may represent extremely extended vesicles; 2) spherules are zoned in water concentration, with water-rich cores; 3) in potassium feldspar megacrysts from Mt. Erebus, the abundance of water in melt inclusions qualitatively coincides with abundance of water in the surrounding crystal, and the abundance of water in the crystal does not seem to vary significantly with crystallographic orientation; 4) water concentration in Mt. Erebus melt inclusions are not homogeneous, and are sensitive to water concentration of neighboring crystals; 5) water in microcline crystals occurs mostly as H_2O molecules, rather than as OH^- anionic complexes. .

Conclusions: FTIR spectroscopy is providing the opportunity to understand the behavior in water in felsic magmas at key times in the evolution of these magmas, including 1) during times of extensive crystallization of major phases such as feldspar, and 2) just prior to explosive eruptions and 3) during periods of rapid quenching, including eruption periods.

References: N.W. Dunbar, K.V. Cashman, and R. Dupre, “Crystallization processes of anorthoclase phenocrysts in the Mount Erebus magmatic system: evidence from crystal composition, crystal size distribution, and volatile contents of melt inclusions,” Volcanological and Environmental Studies of Mount Erebus, Antarctica, Antarctic Research Series, American Geophysical Union, **66**, *129-146*.